TITLE: METHOD OF DETERMINING AVERAGE CURRENT IN A PWM DRIVE

BACKGROUND OF THE INVENTION

PWM (pulse width modulator) drives are often used to drive electromagnetic actuators or devices with coils. The PWM drive is beneficial because it can efficiently drive heavy inductive loads with little power lost in the PWM drive throughout the entire control range (0 to 100% duty cycle). The coil can act on a mechanical object by means of a magnetic field created by the current in the coil. The magnitude of the magnetic field is directly proportional to the current in the coil so it is important to control or monitor this current. The magnitude of the current can be predicted by dividing the average voltage across the coil by an assumed coil resistance, but because the coil resistance is a strong function of temperature and the temperature can change dramatically as the coil is being driven, this prediction is often insufficient. Many applications use current feedback and closed loop control on this feedback.

When a coil is driven by PWM, the current in the coil is constantly changing. The PWM drive applies a square wave voltage pattern to the coil and hence when the voltage is high, the current is increasing, when the voltage is low, the current is decreasing. The PWM frequency is typically much higher than the response time of the mechanical object being acted on by the coil, so the instantaneous current within the cycle of the PWM is not of value, but the average current is important. Consequently, the feedback variable required is the average current. Very often an Infinite Impulse Response (lag, etc.) filter is used on the

feedback signal to yield the average current going to the coil. This inherently adds significant lag to the feedback signal and hence slows the response of the control.

Therefore, there is a need in the art for a method of calculating the average current within the cycle of a PWM that eliminates lag in the feedback signal. By eliminating the lag in the feedback an improved PWM driving circuit would be produced.

Consequently, it is a primary object of the present invention to provide a method of calculating the average current within a PWM cycle using a Finite Impulse Response (FIR) to minimize lag in the feedback signal.

Yet another object of the present invention is to speed up the response of the control of a PWM cycle.

Another object of the present invention is to use a method of calculating an average current within the cycle of a PWM that drives an electrohydraulic valve to improve performance of the valve.

These and other objects, features, or advantages of the present invention will become apparent from the specification and the claims.

BRIEF SUMMARY OF THE INVENTION

The present invention is a method of driving an electrohydraulic valve with a PWM drive. The method includes transmitting a feedback signal to a digitizing device that is a finite impulse response filter that samples the signal. The samples are collected in an accumulator where an average value is calculated and sent to an algorithm. The algorithm controls the pulse width of the PWM signal to drive the coil of the electrohydraulic valve.

BRIEF DESCRIPTION OF THE DRAWINGS

The figure is a schematic block diagram of the method of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a closed loop cycle 10 that has a PWM driven coil of an electrohydraulic valve 12. The coil 12 electrically transmits a feedback signal 14 to the digitizing device with accumulator 16, or Finite Impulse Response filter. The digitizing device 16 sends a signal 18 to the closed loop control algorithm 20. The algorithm 20 then sends a pulse width signal 22 back to the PWM driver 12 to complete the cycle 10.

In operation the cycle 10 begins at the PWM driven coil of the electrohydraulic valve 12 wherein the PWM drive produces a feedback signal 14. The signal is fed into the digitizing device 16. In the digitizing device 16 the signal 14 is sampled at a rate high enough so that multiple samples per PWM period, or a plurality of samples, are taken. Each time a sample is taken, the digital value is added to the accumulator within the digitizing device 16. At a given, fixed location within the PWM cycle 10, the accumulator is divided by the number of samples within the cycle 10. This yields the average value of the current within one cycle 10. This result is passed to the closed loop control algorithm 20 via signal 18 to determine the pulse width of the next cycle 10 via pulse width signal 22. The accumulator is reset to zero and the cycle 10 starts over again.

The digitizing device 16 in a preferred embodiment is an AtoD converter. However, a DSP, a microcontroller, or

any device capable of sampling the feedback signal 14 at a given rate would also be applicable. The closed loop control algorithm 20 in a preferred embodiment preferably would be a PI or PID; however any other algorithm that can determine the pulse width from signal 18 provided by the digitizing device 16 will suffice.

By using the method described, the feedback signal 14 has a lower lag than in prior art devices that use Infinite Impulse Response filters. With this very small lag, the control algorithm 20 is tuned for fast response and is still able to maintain stability. This fast response is increasingly important as total system performance is gaining focus and more and more electronics are used for various types of machine control. Thus the electrohydraulic valve performs at an optimum level. Consequently, all of the stated objectives are achieved.

It will be appreciated by those skilled in the art that other various modifications could be made to the device without the parting from the spirit in scope of this invention. All such modifications and changes fall within the scope of the claims and are intended to be covered thereby.